Research Proposal

Characterization of Suspended Solids and Overcoming Sampling Bias

Problem Title. What are the characteristic ranges in particle size distribution (PSD), specific gravities, and specific surface areas of suspended solids contained in highway runoff?

Problem Statement. Several physical and chemical characteristics of highway runoff are poorly understood. Without statistically significant characterizations of highway runoff quality, it becomes very difficult to design facilities that can effectively remove priority pollutants contained in highways runoff. One important factor in the effectiveness of stormwater treatment methods is the ability to remove and retain a wide range of particle sizes. Historical sampling bias may be interfering with evaluation of treatment methods for removing suspended solids from highway runoff.

The available published data on particle size distributions (PSDs) of highway runoff has shown very high degrees of variability, ranging over several orders of magnitude. When stormwater samples have been collected using automated samplers with peristaltic pumps, the PSD results have been significantly skewed toward finer sediments. The few studies that have collected runoff samples by either collecting all runoff or runoff from a flow splitter have shown much coarser sediment gradations. Evidence from the SR 167, SR 405, and the Lake Union Ship Canal Stormwater Research Facility monitoring efforts indicated that highway runoff might have particle size distributions that are dominated by very fine sediments. It is unknown if these data are truly representative of highway runoff or if they are biased by the sampling method, which may not be able to efficiently collect sediments larger than approximately 0.125 mm (125 microns).

For evaluating BMP effectiveness, this factor may be problematic for accurately evaluating suspended solid capture rates. If the Sansalone (see *Literature Search* below) data are reasonably accurate, automated samplers may be missing up to 80 percent of the suspended solids concentrations in highway runoff. These facts may result in a reduction in the number and variety of treatment options available for projects.

Related questions that could be answered by this research proposal include:

- How are particle size distributions of runoff samples influenced by the method of collection (automated samplers such as ISCOs™ or American Sigmas™, entire event capture using tanks, flow splitters such as the UW/Marr configuration) or the method of analysis (light-blocking laser particle analyzers, wet/dry sieving)?

- How well does total suspended solids (TSS) analysis characterize the mass and PSD of suspended solids contained in highway runoff?

- Are there other physical or chemical characteristics of highway runoff (pH, alkalinity, hardness, ionic composition, etc.) that may influence the treatability of runoff or should influence the design of effective treatment systems for highway runoff?

- Are the physical and chemical characteristics of highway runoff significantly different than runoff from other land uses so that treatment system designs should be appropriately modified?

Literature Search. WSDOT completed an effectiveness monitoring study of a Vortechs® separator on State Route (SR) 405 (average daily traffic (ADT) =150,000) in Bothell, a WSDOT-designed filtration unit designed to fit within highway embankments, a.k.a. the Ecology Embankment on SR 167 in Renton (ADT = 105,000), and Interstate 5 runoff coming from the southbound lanes of the Lake Union ship canal bridge in downtown Seattle (ADT = 250,000). These studies included analyses of PSD using automated samplers with peristaltic pumps to collect flow-weighted composites of runoff. The PSD analyses themselves were conducted using laser refraction technology to estimate the distributions. The results of the SR 405, SR 167, and Interstate 5 PSD analyses were all quite similar – generally 80 percent or more of the particles were found to be fine silts (<20 μm) or smaller.

These PSD results conflict with those published by Sansalone and others, who collected all water and sediments from a small highway catchment near Cincinnati. Sansalone et al. reported that on average less than 20 percent of all particles by weight were comprised of smaller particles smaller than 100 μm and that approximately 75 percent of all particles were larger than 300 μm – considerably coarser PSDs than indicated by WSDOT's monitoring efforts. There appears to be evidence that the PSD results from the SR 405 Vortechs study may not be truly representative of the total range of particle sizes received by the unit.

Observations of sediment levels within the holding tank of the SR 405 Vortechs® unit indicate that sediment is accumulating at a much greater rate than would be predicted from its calculated TSS removal effectiveness. It can be reasonably speculated that this effect may be caused by the collection method itself. The peristaltic pumps may not be able to collect larger sediments that saltate along the bottom of the pipe or ditch (bed load), thereby biasing the results toward smaller particulates. A result of this phenomena would be low apparent TSS removal efficiency numbers, since most BMPs generally remove the larger particulates very efficiently (aside from low specific gravity particles such as packing peanuts, cigarette butts, and leaves), which would not be reflected in the TSS removal data since larger particulates in both influent and effluent would be un-sampled or under-sampled. This is an active topic among many researchers since runoff PSDs can influence both BMP design criteria and empirical BMP effectiveness studies.

Research Methods. Monitor current research for further developments in PSD analysis technologies. One question that is mostly unanswered is how do PSD results differ between laser refraction and physical sieving techniques? Look for ways to set up automated samplers so

that they can capture bed load/ larger particulates efficiently so that overall sampling is representative.

Partnering Opportunities. Low. Most in the regulated community are having difficulty with current regulations and the associated cost burdens. From a technical/engineering perspective, knowing the physical/chemical characteristics of runoff should lead to improved designs, but may expose some common stormwater treatment practices as insufficient to meet certain goals. This may not appeal to many potential partners.

Estimate of Costs and Research Duration. Estimated costs have not been developed, but are expected to be greater than $100,000.

Urgency, Payoff Potential, and Implementation. Research results could be used to improve BMP design guidance in the *Highway Runoff Manual*.

Research Proposer

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